

The Hong Kong Polytechnic University

Subject Description Form

Please read the notes at the end of the table carefully before completing the form.

Subject Code	CBS1D39
Subject Title	Logic as a Foundational Science
Credit Value	3
Level	1
Pre-requisite / Co-requisite/ Exclusion	Exclusion GEC1D36 and GEC1D36M and CBS1D39M Logic as a Foundational Science
Objectives	<p>This subject aims at teaching logic as a rigorous academic subject and a foundational science. The major areas of modern logic will be covered, and the many applications of logic in areas such as mathematics, linguistics, electronic engineering, computer programming will be demonstrated. In particular, the objectives of this subject are as follows:</p> <ol style="list-style-type: none"> (1) to develop students' ability in logical thinking, and equip them with academic tools that can help them to carry out logical thinking systematically, clearly, and precisely; (2) to give students a basic knowledge in various branches of modern logic, including propositional logic, predicate logic, and Boolean algebra; (3) to help students understand and appreciate the practical applications of logic in various areas such as the foundation of mathematics, linguistics, problem solving, switching circuit design, digital circuit design, computational theory, computer programming, and evaluating theoretical hypotheses in natural science.
Intended Learning Outcomes (Note 1)	<p>Upon completion of the subject, students will be able to:</p> <ol style="list-style-type: none"> (a) master the basic skills of logic inference, derivation, and validation in the main branches of logic, such as propositional calculus, predicate calculus, and Boolean algebra; (b) represent ideas and thoughts with the language of logic, and translate back and forth between symbolic logic and natural language; (c) solve logical problems with the aids of mathematical logic; (d) judge and determine the validity of logical inferences in various forms; (e) appreciate the versatility as well as limitation of logic, and its role and place in the human intellect. <p>Students are required to read the two prescribed textbooks, which include exercises that they are required to do. Besides contributing to the enhancement of reading literacy, the studying of this subject also helps to enhance their numeric literacy (sometimes called numeracy) and logical literacy.</p>

**Subject Synopsis/
Indicative Syllabus**

(Note 2)

1. Introduction
 - a. Logic as a rigorous science subject
 - b. The history of logic and the rise of modern mathematical logic
 - c. The branches of logic
 - d. Applications of logic in mathematics, linguistics, problem solving, switching circuit design, digital circuit design, computational theory, and programming
2. Propositional Calculus
 - a. Atomic statements and compound statements
 - b. Logical operators: AND, OR, NOT, IF ... THEN, and IF AND ONLY IF
 - c. Logic puzzles and logical derivation
 - d. Language and logic
 - e. Axiomatizations and theorem proving
 - f. Truth-table method, *reductio* method, tree method, and natural deduction
3. Syllogistic Logic
 - a. Quantifiers: ALL, SOME, and NO
 - b. Forms of syllogisms
 - c. Venn diagram method
 - d. Edwards-Venn diagrams
4. Predicate Calculus
 - a. Subject and predicate
 - b. Quantifiers
 - c. Universe of discourse
 - d. Multiple quantification
 - e. Relations and identity
 - f. Rules of derivation and validity: truth trees and natural deduction
5. Boolean systems and numerical systems
 - a. Boole's system
 - b. Boolean monadic predicate logic
 - c. Boolean propositional logic
 - d. Boolean algebra
 - e. Numerical systems
 - f. The binary system
 - g. Binary arithmetic

	<ul style="list-style-type: none"> 6. Logic circuits <ul style="list-style-type: none"> a. Switches b. Logic gates c. Logic circuits d. Logical operations, such as ADD and COMPARE e. Logical circuit design, such as ADDER, ENCODER, DECODER 7. Logic and the foundation of mathematics <ul style="list-style-type: none"> a. The project of logicism: the reduction of mathematics to logic b. Axioms and theorems in formal arithmetic c. Logical proof of theorems in arithmetic d. Peano, Frege, Russell, and Gödel 8. Computability and computing <ul style="list-style-type: none"> a. Algorithms b. Turing Machines c. The halting problem d. Decision problems e. Logic programming f. Automatic theorem proving g. Knowledge representation h. Knowledge processing 9. Understanding and evaluating scientific hypotheses <ul style="list-style-type: none"> a. Data and hypotheses b. The logic of confirmation and falsification c. Models and theories d. Prediction from model e. Deductive-nomological explanation f. Crucial experiments g. Model development 10. Logic and beyond <ul style="list-style-type: none"> a. Logic as a foundational subject b. Gödel's proof of consistency and completeness of logical systems c. Alternative logics d. The limitations of logic e. The meaning and implications of Gödel's Incompleteness Theorem
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<p>Teaching/Learning Methodology</p> <p>(Note 3)</p>	<p>The basic concepts, principles, and techniques of mathematical logic will be explained and discussed in the lectures. Emphasis will be put on the precise understanding and representation of logical problems, correct derivation of logical conclusions, and the construction of impeccable proofs. Students will be required to do preparatory exercises before the lecture, and revision exercises after the class. Difficult problems will be discussed in the tutorial.</p> <p>Logic has to be learnt through practice. In order to learn logic, students have to engage themselves actively in thinking through the logical problems. They are provided with many exercise problems to work on, and selected problems will be attempted together and discussed in depth in the tutorial. Solutions will be distributed to students at a later stage. Students are encouraged to raise problems for discussion both in the lecture and in the tutorial.</p> <p>Besides the exercises, students are also required to write an essay with reference to the application of logic and its limitation in an area chosen by the student.</p> <p><u>Writing Requirement:</u> As a “Writing Intensive” subject, students will be required to produce a substantial paper, which will undergo several drafts, the earlier drafts will be submitted for the comments of the ELC teacher, and the final version for the subject teacher well before the end of the semester. Two grades will be assigned, one by the ELC teacher based upon an assessment of the student’s participation in the drafting process (worth one-third of the essay grade) and one by the subject teacher based on content (worth two-third of the essay grade). The final version will be accompanied with a copy of the earlier drafts to assess “progress”.</p> <p><u>Reading Requirement:</u> Reading is required for successfully completing the assigned exercises and the writing project. In addition, questions in the mid-term quiz will require students to have sufficient mastery of the content of the required reading which they have to do on their own as well as the subject-specific knowledge and thinking skills they taught in the class.</p>																																								
<p>Assessment Methods in Alignment with Intended Learning Outcomes</p> <p>(Note 4)</p>	<table border="1"> <thead> <tr> <th rowspan="2">Specific assessment methods/tasks</th> <th rowspan="2">% weighting</th> <th colspan="5">Intended subject learning outcomes to be assessed (Please tick as appropriate)</th> </tr> <tr> <th>a</th> <th>b</th> <th>c</th> <th>d</th> <th>e</th> </tr> </thead> <tbody> <tr> <td>1. Tutorial and exercise performance</td> <td>40%</td> <td>✓</td> <td>✓</td> <td>✓</td> <td>✓</td> <td></td> </tr> <tr> <td>2. Mid-term Quiz</td> <td>20%</td> <td>✓</td> <td>✓</td> <td>✓</td> <td>✓</td> <td></td> </tr> <tr> <td>3. Essay</td> <td>40% (in which 10% of the assessment will be conducted by ELC)</td> <td>✓</td> <td>✓</td> <td></td> <td></td> <td>✓</td> </tr> <tr> <td>Total</td> <td>100 %</td> <td colspan="5"></td> </tr> </tbody> </table>	Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					a	b	c	d	e	1. Tutorial and exercise performance	40%	✓	✓	✓	✓		2. Mid-term Quiz	20%	✓	✓	✓	✓		3. Essay	40% (in which 10% of the assessment will be conducted by ELC)	✓	✓			✓	Total	100 %					
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	<p>Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:</p> <p>Different types of questions will be set in the exercises so that, taken as a whole, intended learning outcomes (a) to (d) would be assessed. For example: problems in propositional calculus, predicate calculus and Boolean algebra; translation of statements and arguments in the natural language of English to the artificial language of logic; testing of the validity of an argument; analyzing and solving reasoning problems with mathematical logic, etc. The same applies to the quiz. As for intended learning outcome (e), it will be assessed by the student's essay.</p> <p>In order to pass this subject, students must pass the writing component, i.e., attain a minimum grade "D" in the writing component.</p>	
<p>Student Study Effort Expected</p>	Class contact:	
	<ul style="list-style-type: none"> ▪ Lectures 	26 Hrs.
	<ul style="list-style-type: none"> ▪ Tutorials 	13 Hrs.
	Other student study effort:	
	<ul style="list-style-type: none"> ▪ Completing exercises & self-study 	40 Hrs.
	<ul style="list-style-type: none"> ▪ Reading 	40 Hrs.
	<ul style="list-style-type: none"> ▪ Writing 	15 Hrs.
	Total student study effort	134 Hrs.
<p>Reading List and References</p>	<p>Required Reading (Textbooks):</p> <p>Robert P. McArthur. <i>From Logic to Computing</i>, Belmont, CA: Wadsworth, 1991.</p> <p>Yu, Kam Por, <i>Logic</i>, Singapore: McGraw-Hill, 2007.</p> <p>Other References:</p> <p>Jens Allwood, Lars-Gunnar Andersson, Östen Dahl, <i>Logic in Linguistics</i>, Cambridge: Cambridge University Press, 1977.</p> <p>Marren L. Bittinger, <i>Logic, Proof, and Sets</i> (Second Edition), Reading, MA: Addison Wesley Publishing Co., 1982.</p> <p>George S. Boolos and Richard C. Jeffrey, <i>Computability and Logic</i> (Second Edition), Cambridge: Cambridge University Press, 1980.</p> <p>J. N. Crossley <i>et al.</i>, <i>What is Mathematical Logic?</i>, New York: Dover Publications, 1990.</p> <p>Martin Davis, <i>Engines of Logic: Mathematicians and the Origin of the Computer</i>, New York: W. W. Norton, 2000.</p> <p>K. J. Devlin, <i>Sets, Functions and Logic: Basic Concepts of University Mathematics</i>, London: Chapman and Hall, 1981.</p> <p>Graeme Forbes, <i>Modern Logic</i>, New York: Oxford University Press, 1994.</p>	

	<p>Jean H. Gallier, <i>Logic for Computer Science: Foundations of Automatic Theorem Proving</i>, New York: Harper & Row, 1986.</p> <p>Martin Gardner, <i>Logic Machines and Diagrams</i> (Second Edition), Brighton, UK: The Harvester Press, 1983.</p> <p>J. R. Gibson, <i>Electronic Logic Circuits</i> (Second Edition), London: Edward Arnold, 1983.</p> <p>Ronald N. Giere, John Bickle, and Robert F. Mauldin, <i>Understanding Scientific Reasoning</i> (Fifth Edition), Belmont, CA: Wadsworth, 2006.</p> <p>John R. Gregg, <i>Ones and Zeros: Understanding Boolean Algebra, Digital Circuits, and the Logic of Sets</i>, New York: IEEE Press, 1998.</p> <p>Carl G. Hempel, <i>Aspects of Scientific Explanation</i>, New York: The Free Press, 1965.</p> <p>Jean van Heijenoort (ed.), <i>From Frege to Gödel: A Source Book in Mathematical Logic, 1879-1931</i>, Cambridge, MA: Harvard University Press, 1967.</p> <p>Colin Howson, <i>Logic with Trees: An Introduction to Symbolic Logic</i>, London: Routledge, 1997.</p> <p>Richard Jeffrey, <i>Formal Logic: Its Scope and Limits</i> (Second Edition), New York: McGraw-Hill, 1989.</p> <p>E. J. Lemmon, <i>Beginning Logic</i>, Middlesex, UK: Thomas Nelson and Sons, 1979.</p> <p>Elliott Mendelson, <i>Introduction to Mathematical Logic</i> (Third Edition), Monterey, CA: Wadsworth and Brooks/Cole, 1987.</p> <p>Elliott Mendelson, <i>Boolean Algebra and Switching Circuits</i>, New York: McGraw-Hill, 1987.</p> <p>Ernest Nagel, <i>The Structure of Science: Problems in the Logic of Scientific Explanation</i> (Second Edition), Indianapolis, IN: Hackett, 1979.</p> <p>Ernest Nagel and James R. Newman, <i>Gödel's Proof</i>, New York: New York University Press, 1958.</p> <p>John Nolt and Dennis Rohatyn, <i>Logic</i>, New York: McGraw-Hill, 1988.</p> <p>Karl R. Popper, <i>The Logic of Scientific Discovery</i>, London: Hutchinson, 1972.</p> <p>W. V. Quine, <i>Methods of Logic</i> (Revised Edition), London: Routledge & Kegan Paul, 1978.</p> <p>Steve Reeves and Michael Clarke, <i>Logic for Computer Science</i>, Wokingham, UK: Addison-Wesley Publishing Co., 1990.</p> <p>Rudy Rucker, <i>Mind Tools: The Mathematics of Information</i>, Harmondsworth: Penguin Books, 1988.</p> <p>Morton L. Schagrin, William J. Rapaport, and Randall R. Dipert, <i>Logic: A Computer Approach</i>, New York: McGraw-Hill, 1985.</p> <p>S. G. Shanker, <i>Gödel's Theorem in Focus</i>, London: Routledge, 1989.</p> <p>Patrick Shaw, <i>Logic and Its Limits</i> (Second Edition), Oxford: Oxford University Press, 1997.</p> <p>A. Thayse, <i>From Standard Logic to Logic Programming: Introducing a Logic Based Approach to Artificial Intelligence</i>, Chichester, UK: John Wiley & Sons, 1988.</p>
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	<p>Mike Thorne, “Back to the Future: Mathematical Logic and Computers”, in Christine Bondi, <i>New Applications of Mathematics</i>, Harmondsworth: Penguin Books, 1991, pp. 163-201.</p> <p>Hao Wang, <i>Popular Lectures on Mathematical Logic</i>, New York: Dover Publications, 1993.</p>
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Note 1: Intended Learning Outcomes

Intended learning outcomes should state what students should be able to do or attain upon completion of the subject. Subject outcomes are expected to contribute to the attainment of the overall programme outcomes.

Note 2: Subject Synopsis/ Indicative Syllabus

The syllabus should adequately address the intended learning outcomes. At the same time over-crowding of the syllabus should be avoided.

Note 3: Teaching/Learning Methodology

This section should include a brief description of the teaching and learning methods to be employed to facilitate learning, and a justification of how the methods are aligned with the intended learning outcomes of the subject.

Note 4: Assessment Method

This section should include the assessment method(s) to be used and its relative weighting, and indicate which of the subject intended learning outcomes that each method purports to assess. It should also provide a brief explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes.

Subject Offering Department	CBS
Cluster Area	<p>Please check the box(es) below to indicate the cluster area(s) the subject contributes in a major way:</p> <p><input type="checkbox"/> Human Nature, Relations and Development [CAR(A)]</p> <p><input checked="" type="checkbox"/> Science, Technology and Environment [CAR(D)]</p> <p><input type="checkbox"/> Chinese History and Culture [CAR(M)]</p> <p><input type="checkbox"/> Cultures, Organisations, Societies and Globalisation [CAR(N)]</p>
Medium of Instruction	English
Requirements intended to fulfil	<p><input type="checkbox"/> China-Study Requirement (CSR)</p> <p><input checked="" type="checkbox"/> English Reading (ER) and English Writing (EW)</p> <p><input type="checkbox"/> Chinese Reading (CR) and Chinese Writing (CW)</p>